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ABSTRACT

Crustal Evolution Education Project (CEEP) modules were designed to: (1) provide students with the methods and results of continuing investigations into the composition, history, and processes of the earth's crust and the application of this knowledge to man's activities and (2) to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift, and plate tectonics. Each module consists of two booklets: a teacher's guide and student investigation. The teacher's guide contains all of the information present in the student investigation booklet as well as: (1) a general introduction; (2) prerequisite student background; (3) objectives; (4) list of required materials; (5) background information; (6) suggested approach; (7) procedure, recommending two 45-minute class periods required; (8) summary questions (with answers); (9) extension activities; and (10) list of references. Using prepared written material contained in this module, students formulate predictions based on the Conventional View of the Earth and Plate Tectonics Theory as one way to decide which is the better theory. Then, they are given data as a way to check out their predictions. (Author/JN)

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CRUSTAL EVOLUTION EDUCATION PROJECT

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How Do Scientists Decide Which Is The Better Theory?

TEACHER'S GUIDE

Catalog No. 34W1011

For use with Student Investigation 34W1111
Class time: two 45-minute periods

Developed by
THE NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

Produced and Distributed by
Ward's Natural Science Establishment, Inc. Rochester, NY • Monterey, CA

How Do Scientists Decide Which Is The Better Theory?

SE 038121

NAGT Crustal Evolution Education Project

Edward C. Stoever, Jr., Project Director

Welcome to the exciting world of current research into the composition, history and processes of the earth's crust and the application of this knowledge to man's activities. The earth sciences are currently experiencing a dramatic revolution in our understanding of the way in which the earth works. CEEP modules are designed to bring into the classroom the methods and results of these continuing investigations. The Crustal Evolution Education Project began work in 1974 under the auspices of the National Association of Geology Teachers. CEEP materials have been developed by teams of science educators, classroom teachers, and scientists. Prior to publication, the materials were field tested by more than 200 teachers and over 12,000 students.

Current crustal evolution research is a breaking story that students are living through today. Teachers and students alike have a unique opportunity through CEEP modules to share in the unfolding of these educationally important and exciting advances. CEEP modules are designed to provide students with appealing firsthand investigative experiences with concepts which are at or close to the frontiers of scientific inquiry into plate tectonics. Furthermore, the CEEP modules are designed to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift and plate tectonics.

We know that you will enjoy using CEEP modules in your classroom. Read on, and be prepared to experience a renewed enthusiasm for teaching as you learn more about the living earth in this and other CEEP modules.

About CEEP Modules...

Most CEEP modules consist of two booklets, a Teacher's Guide and a Student Investigation. The Teacher's Guide contains all the information and illustrations in the Student Investigation, plus sections printed in color, intended only for the teacher, as well as answers to the questions that are included in the Student Investigation. In some modules, there are illustrations that appear only in the Teacher's Guide, and these are designated by figure letters instead of the number sequence used in the Student Investigation.

For some modules, maps, rulers and other common classroom materials are needed, and in varying quantities according to the method of presentation. Read over the module before scheduling its use in class and refer to the list of MATERIALS in the module.

Each module is individual and self-contained in content, but some are divided into two or more parts for convenience. The recommended length of time for each module is indicated. Some modules require prerequisite knowledge of some aspects of basic earth science, this is noted in the Teacher's Guide.

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How Do Scientists Decide Which Is The Better Theory?

INTRODUCTION

The major purpose of this activity is to help students recognize that a new theory is not just "invented" and, in turn, automatically accepted by those working in the discipline. To meet this purpose, the students are involved in using one theory-testing strategy, namely, formulating and testing predictions, as a means of deciding whether the *Conventional View of the Earth*, or *Plate Tectonics Theory* is the better, more useful way of thinking about the dynamics of the earth.

Daily on television, in magazines, newspaper, radio, billboards and elsewhere, we all see new ads that encourage us to buy the product advertised. Why? Because it's new! If it's new it must be better, right?

Sometimes these ads go beyond trying to encourage us to buy something just because it's new. Reasons may be given why the new product is better than an older one. In the case of a new automobile; for example, the ad may point out that the car has better handling; that it goes farther on a gallon of gas; that it has a better, more reliable or powerful engine; that it offers better passenger safety features; and so on.

If you were about to buy your first car and had the money to do so, what kinds of things would you look for?

Invite the students to report the kinds of things they'd look for in their first car. List their comments on the chalkboard. Only a few criteria need be recorded.

When you're trying to decide whether one car is better than another, you could use your own list of things you'd look for to compare the cars you're thinking about. Then you'd be ready to decide which car is the better one.

In science it is not unusual that more than one theory can explain a certain phenomenon. Or a new theory may be in conflict with an existing theory. Just as you decided which car would be best, scientists must decide which theory is best, and the newer theory isn't always the one chosen. The purpose of this activity is to help you experience one of the ways scientists decide which is the better theory, when more than one theory may seem correct.

PREREQUISITE STUDENT BACKGROUND

While no in-depth knowledge of the Conventional View of the Earth or Plate Tectonics Theory is required for this instructional activity, the students should have had some exposure to these ideas prior to participation so they are aware that a new and significantly different theory about the earth's dynamics is currently being tested.

OBJECTIVES

After you have completed this activity, you should be able to:

1. Name one kind of test a scientist may use on a theory.
2. Describe or give an example of how this test is used to decide which is the better theory.

MATERIALS

Cardboard (optional)

BACKGROUND INFORMATION

Geology, like other sciences, is not static. The dynamic nature of the discipline is evident not only in the continuing stream of new data, but more significantly in the evolution and general acceptance of new theories. It is our concern that students miss much of the excitement and challenge of an area of science if the emphasis of instruction centers on generally adopted theories alone. Students should also learn about and participate in using theory-building and theory-testing strategies common to the discipline of geology.

SUGGESTED APPROACH

This activity is to be used with the entire class where students can work at desks or laboratory tables. The students can participate as individuals, or they may be invited to work in groups of two during the part of the lesson in which they formulate their theory-based predictions.

PROCEDURE

Students will be using prepared written material contained in this module to formulate predictions based on the Conventional View of the Earth and the Plate Tectonics Theory as one way to decide which is the better theory. Then, they are given data as a way to check out their predictions.

Key words: sediment, prediction, Conventional View of the Earth, Plate Tectonics Theory

Time required: two 45-minute periods

Materials: none.

Although no materials are required, you may prepare the following words on pieces of cardboard. These are then used during the activity in order to emphasize the judgments made about the theory. Of course, this information can simply be written on the chalkboard or overhead transparency if desired.

PLATE TECTONICS THEORY

CONVENTIONAL VIEW OF THE EARTH

ACCURATE PREDICTION: AGE OF ROCKS

ACCURATE PREDICTION: SEDIMENT THICKNESS

It is important to emphasize that as the students formulate their predictions to test the Conventional View of the Earth and Plate Tectonics Theory, they formulate predictions that follow from the theory being tested rather than to formulate a prediction they feel is correct.

Ask the students to read only the first two paragraphs and the section entitled: TWO THEORIES ABOUT THE EARTH.

To make a **prediction** is to use a theory to forecast data. To make a prediction is to tell what will happen in an experiment or observation before the experiment or observation is actually carried out. Predictions are educated guesses that follow from a theory. For example, imagine that you wanted to test a theory about the geologic history of a certain place and the theory stated that at one time that place was part of an ocean. From that theory, you would predict that the area should contain fossils of sea life that lived in that ocean. If such fossils were then found, the prediction would have been correct. A correct prediction supports a theory.

Depending on the group, the additional considerations of accuracy and precision of the prediction may also be introduced.

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Now you are going to participate in an activity in which you will use predicting to help you decide which is the better theory, the **Conventional View of the Earth** or the **Plate Tectonics Theory.** In order to refresh your memory about each of these theories, a brief review is provided below.

TWO THEORIES ABOUT THE EARTH

The Conventional View of the Earth

Historically, the generally accepted view of the earth has been that it is made of a continuous, relatively rigid crust much like the skin of an apple. This position holds that beneath the crust is a molten fluid mass that makes up most of the volume of the planet. The surface of the earth is, therefore, somewhat stable and unchanging, except for erosional and mountain building forces that act independently in relatively small areas of the surface of the earth. Though this view of the earth is not a clearly defined theory statement, we will call it the Conventional View and consider it a theory.

According to this theory, the earth was formed as a molten mass which cooled. Cooling of the surface resulted in the solidification of the crust. Thus, all the oldest rocks were formed at the same time. Because cooling usually results in shrinking or contraction, this shrinking caused a wrinkling of the crust that led to the formation of the topographical features we recognize as mountains and valleys.

Since the time the earth cooled—when rocks were formed—erosional and mountain building forces have continually made changes in the face of the earth. The formation of **sediments** began at that time and have continued (except for local interruptions) throughout the history of the earth. Sediment is fragments of rocks and minerals, usually deposited in water.

The Plate Tectonics Theory

More recently in geology, the Plate Tectonics Theory about the nature of the earth has been proposed. Like the Conventional View, this new view also considers the earth as consisting of a thin crust with a molten core, but it differs from the Conventional View in that the crust is believed to be made of a series of about 12 to 14 relatively rigid sections or plates. Furthermore, these plates are believed to be in constant motion in relation to each other. Though this relative motion is very slow when compared to the things we see moving about us daily, it suggests that these plates don't stay in the same place, nor do they stay the same size or exactly the same shape. Plates continuously get new material at ridges and lose older material at trenches. Thus, rocks are being formed at the ridges throughout the life of the planet. Existing plates may, therefore, increase or decrease in surface area. In some locations, new plates are being formed. In some cases, evidence suggests that plates have completely disappeared.

You should conclude this first section by inviting the students to raise any questions for clarification about the two theories. You should point out the major differences between these two theories, emphasizing that the Conventional View holds that the crust is a single continuous piece while the Plate Tectonics Theory views the crust as made up of a series of plates that move in relation to each other.

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Ask the students to complete the section entitled Prediction Test #1, stopping work after they complete the two predictions and rationales. Inform them that they are to complete the predictions and rationales. Emphasize that the prediction they select should be the one that follows from the theory being tested, i.e., "What would we find if the ______ Theory were correct?", rather than the prediction they feel is correct.

Prediction Test #1: Dating Core Samples

You are part of a geologist's team which has received a grant to drill and date five core samples from an area just west of the East Pacific Rise and south of the Galapagos Fracture Zone.

Your team is going to use this opportunity to test the Conventional View and Plate Tectonics Theory. You will test these theories by predicting the relative ages of igneous rock cores that will be found at the drill sites. See Figure 1. Your task is to use these two theories to select and report the predictions you feel best follow from each theory. In addition, you will also be invited to discuss why you chose that particular prediction.

Using the **Conventional View,** check the following prediction that best indicates the relative ages of the sediment cores to be taken from drill sites A through E in Figure 2.

A B C D E

______ #1 oldest ⟷ youngest

__☑__ #2 youngest ⟷ oldest

__√__ #3 All sites will be the same.

______ #4 Each of the sites will be different ages, but ages will be randomly distributed.

I predict this will be found because the **Conventional View** says:

All rocks were formed at the same time.

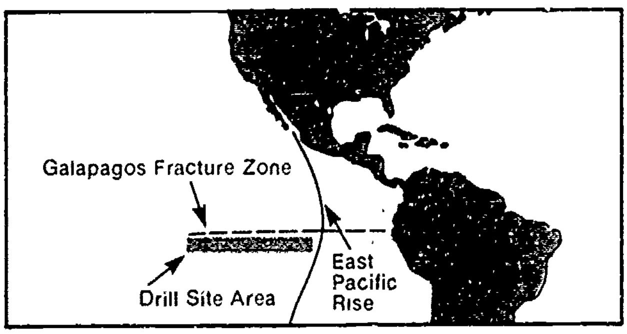

Figure 1. Drill site area for dating core samples.

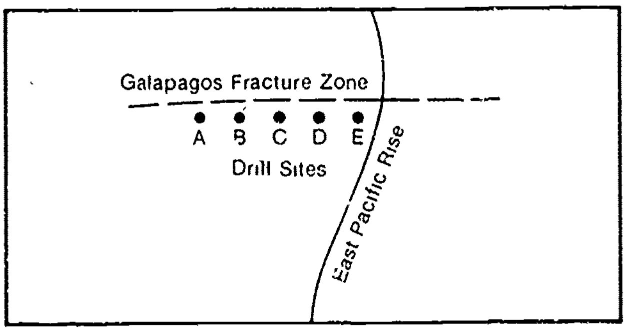

Figure 2. The drill sites will be approximately 500 km apart, with Site E at 500 km from the ridge and Site A at 2500 km from the ridge.

Using the **Plate Tectonics Theory**, check the following prediction that best indicates the relative age of the cores to be taken from drill sites A through E.

A B C D E

✓ #1 oldest ⟷ youngest

____ #2 youngest ⟷ oldest

____ #3 All sites will be the same.

____ #4 Each of the sites will be different ages, but ages will be randomly distributed.

I predict this will be found because the **Plate Tectonics Theory** says:

The earth's plates are continuously moving, and new material is being formed at the ridges.

After the students have selected their predictions and recorded their rationales for each one, you should invite various students to report their predictions and their rationales. Students whose predictions differ from those reported should also be invited to report.

As the students report their predictions and rationales, you should provide feedback by indicating that according to the Conventional View, the cores would be the same age. The Conventional View holds that all rocks on the earth were formed at the same time (excluding, of course, those formed by local mountain building, etc.). According to the Plate Tectonics Theory, however, the cores should be younger the closer they are to the ridge because that theory holds that rocks are continuously being formed at the ridges. The emphasis of this feedback is not on which prediction is correct but rather on the formulation of a prediction that follows from a given theory. As you give the feedback, you should point out how each prediction follows from each theory.

When this discussion about predictions and rationale is completed, inform the students that having completed the drilling and the dating of the cores, their team has found the relative ages of the rocks to be as follows (this information may be written on the chalkboard):

A B C D E

oldest ⟷ youngest

You should now pose the following questions:

In view of this data, which theory seems to be the best one so far?

- **The Conventional View of the Earth?**
- **The Plate Tectonics Theory?**
- **Why?**

Guide the students toward the conclusion that the Plate Tectonics Theory produced the most accurate prediction in relation to the age of the rocks at those sites. This, therefore, is viewed as support for the Plate Tectonics Theory.

Place the ACCURATE PREDICTION: AGE OF ROCKS card under the heading Plate Tectonics Theory on the bulletin board; or this information may be written on the chalkboard or on an overhead transparency under the heading, Plate Tectonics Theory.

Prediction Test #2: Measuring Sediment Thickness

This second part of the activity follows the same format as the first part. That is, students select their predictions and formulate their rationales. After reporting time, you provide the data. Part 2 concludes as you invite the students to make the judgment as to which is the better theory.

Ask the students to complete Prediction Test #2, Measuring Sediment Thickness. They should not read ahead to the summary.

While your team was preparing for your trip to take core samples, the National Science Foundation contacted your group to request that you also measure the thickness of the sediment at those sites. In reviewing this request, it seems that this will give you another opportunity to test the Conventional View and Plate Tectonics Theory by predicting some other data. Since this request includes additional funding to support the added work, your team agrees to gather these additional data.

Before you make your prediction about the sediment thicknesses using the two theories, review the drill core plan. (See Figure 2.)

Using the **Conventional View,** check the following prediction that best indicates the relative thickness of the sediment from drill sites A through E.

A • B • C • D • E •

_____ #1 ← least sediment thickness — greatest sediment thickness →

_____ #2 ← greatest sediment thickness — least sediment thickness →

__√__ #3 Sediment thickness the same at all sites.

_____ #4 Sediment thickness different at each site, but no pattern to thickness.

I predict this will be found because the **Conventional View** says:

Sediment deposits were formed at the same time and would be uniform in thickness.

Using the **Plate Tectonics Theory,** check the following prediction that best indicates the relative thickness of the sediment from drill sites A through E.

A • B • C • D • E •

_____ #1 ← least sediment thickness — greatest sediment thickness →

__√__ #2 ← greatest sediment thickness — least sediment thickness →

_____ #3 Sediment thickness the same at all sites.

_____ #4 Sediment thickness different at each site, but no pattern to thickness.

I predict this will be found because the **Plate Tectonics Theory** says:

Since new crustal material is being formed at the ridge and is therefore youngest, more sediment would have time to accumulate farther from the ridge, on top of older crustal material.

It may be worthwhile to discuss the origin of the sediments on the ocean floor. Sediments which cover the ocean floor settle out of seawater in the open ocean (pelagic sediments) or come directly from land (terrigenous sediments). Terrigenous sediments are dominant only around the margins of the ocean basins. The sediment cores on which these student activities are based are principally made of pelagic sediments. The pelagic sediments making up the cores were largely derived from the remains of organisms whose shells settled to the ocean floor. The cores do contain some other minor constituents of sedimentary nature.

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After the students have selected their predictions and recorded their rationales for each one, invite them to report their predictions and their rationales. Students whose predictions differ should be invited to report. Give feedback to the students by indicating that according to the Conventional View, the sediment thickness would be about the same because that theory holds that sediment deposits began to form at the same time and would form uniformly, excluding, of course, local variations. According to the Plate Tectonics Theory, the sediments should be thicker farther away from the ridge because the newer rocks closer to the ridge would have had less time to accumulate sediment deposits. Again, the emphasis of this feedback is on the formulation of a prediction that follows from a theory rather than first deciding which theory is the better one.

As you give the feedback, emphasize how the different theories yield quite different predictions with reference to sediment thickness.

When this discussion about predictions and rationale is completed, inform the students that having completed the checking of sediment thicknesses of the cores, the relative sediment thicknesses are found to be as follows (this information may be written on the chalkboard):

A • B • C • D • E •

most sediment ←——————→ least sediment

You should now pose the following questions:

In view of these data, which theory seems to be the best one?

- The Conventional View of the Earth?
- The Plate Tectonics Theory?
- Why?

Guide the students toward the conclusion that the Plate Tectonics Theory produced the most accurate prediction in relation to sediment thickness at these sites. This, therefore, is viewed as support for the Plate Tectonics Theory.

Place the ACCURATE PREDICTION: SEDIMENT THICKNESS card under the heading Plate Tectonics Theory on the bulletin board; or this information may be written on the chalkboard or on an overhead transparency under the appropriate heading, Plate Tectonics Theory.

Let's review what you have done in this exercise. You chose one theory over another. The Plate Tectonics Theory makes accurate predictions more often than the Conventional View of the Earth. You chose the Plate Tectonics Theory because it made the best predictions. The more accurately a theory predicts, the more confidence you have in the theory.

Other ways to judge a theory might be:

1) It accounts for more or all of the present data better than the other theory or theories.

2) It accounts for new data better than the other theory or theories.

3) It is accepted by more scientists who work in that science.

Usually one theory is judged better than another because it holds up better under several different tests. However, based on this activity, your degree of confidence in a theory depends upon how well it predicts. The more correct predictions, the more confidence you should have in the theory.

During closing comments, emphasize that theories aren't just tested, then accepted or rejected. Rather, it's a matter of continually testing and yielding increased substantiation for one theory that begins to lead to the judgment that one theory is better than another, becoming generally accepted until a better theory comes along.

It's a common view in science that a good theory is one that holds up long enough to get you to a better theory. Thus, science is an endless search for a better theory. Using the prediction test is one way scientists determine when they've found one.

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SUMMARY QUESTIONS

1. You are a geologist and have a theory that states, "new ocean floor material is being created at mid-ocean ridges and destroyed at trenches." One prediction you might make is that all ocean floor material is less than 200 million years old. How could you check your theory?

Most students want the age of the ocean floor rocks checked at different locations. This is a satisfactory answer but knowing the ages of the ocean floor rocks does not necessarily prove the theory.

2. Explain how predictions can be used to strengthen your confidence in a theory.

A theory which leads to predictions that come true most of the time wins our confidence. If the predictions were more often wrong than correct, we would have little confidence in the theory.

3. A geologist has a theory that states "the continents are not drifting." How could you check out this theory? How confident would you be in your results?

There is no way to check this theory directly. Therefore, any suggestions made by the students must be accepted and evaluated on the basis of their logic.

EXTENSIONS

Using data about paleomagnetic anomalies, heat flow, seismicity or volcanic activity, make predictions using the two theories.

Review positions taken by noted geologists and geophysicists in various magazines regarding both theories as another way to decide which is the better theory.

REFERENCES

Trefil, J S., 1978, A consumer's guide to pseudo-science. *Saturday Review*, v. 5, no. 15 (Apr. 29), p. 5.

Wyllie, P.J., 1976, *The way the earth works: an introduction to new global geology and its revolutionary development.* New York, John Wiley and Sons, Inc., 296 p.

NAGT Crustal Evolution Education Project Modules

CEEP Modules are listed here in alphabetical order. Each Module is designed for use in the number of class periods indicated. For suggested sequences of CEEP Modules to cover specific topics and for correlation of CEEP Modules to standard earth science textbooks, consult Ward's descriptive literature on CEEP. The Catalog Numbers shown here refer to the CLASS PACK of each Module consisting of a Teacher's Guide and 30 copies of the Student Investigation. See Ward's descriptive literature for alternate order quantities.

CEEP Module	Class Periods	CLASS PACK Catalog No.
• A Sea-floor Mystery: Mapping Polarity Reversals	3	34 W 1201
• Continents And Ocean Basins: Floaters And Sinkers	3-5	34 W 1202
• Crustal Movement: A Major Force In Evolution	2-3	34 W 1203
• Deep Sea Trenches And Radioactive Waste	1	34 W 1204
• Drifting Continents And Magnetic Fields	3	34 W 1205
• Drifting Continents And Wandering Poles	4	34 W 1206
• Earthquakes And Plate Boundaries	2	34 W 1207
• Fossils As Clues To Ancient Continents	2-3	34 W 1208
• Hot Spots In The Earth's Crust	3	34 W 1209
• How Do Continents Split Apart?	2	34 W 1210
• How Do Scientists Decide Which Is The Better Theory?	2	34 W 1211
• How Does Heat Flow Vary In The Ocean Floor?	2	34 W 1212
• How Fast Is The Ocean Floor Moving?	2-3	34 W 1213
• Iceland: The Case Of The Splitting Personality	3	34 W 1214
• Imaginary Continents: A Geological Puzzle	2	34 W 1215
• Introduction To Lithospheric Plate Boundaries	1-2	34 W 1216
• Lithospheric Plates And Ocean Basin Topography	2	34 W 1217
• Locating Active Plate Boundaries By Earthquake Data	2-3	34 W 1218
• Measuring Continental Drift: The Laser Ranging Experiment	2	34 W 1219
• Microfossils, Sediments And Sea-floor Spreading	4	34 W 1220
• Movement Of The Pacific Ocean Floor	2	34 W 1221
• Plate Boundaries And Earthquake Predictions	2	34 W 1222
• Plotting The Shape Of The Ocean Floor	2-3	34 W 1223
• Quake Estate (board game)	3	34 W 1224
• Spreading Sea Floors And Fractured Ridges	2	34 W 1225
• The Rise And Fall Of The Bering Land Bridge	2	34 W 1227
• Tropics In Antarctica?	2	34 W 1228
• Volcanoes: Where And Why?	2	34 W 1229
• What Happens When Continents Collide?	2	34 W 1230
• When A Piece Of A Continent Breaks Off	2	34 W 1231
• Which Way Is North?	3	34 W 1232
• Why Does Sea Level Change?	2-3	34 W 1233

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CRUSTAL EVOLUTION EDUCATION PROJECT

NAME DATE

Student Investigation
Catalog No. 34W1111

How Do Scientists Decide Which Is The Better Theory?

INTRODUCTION

Daily on television, in magazines, newspaper, radio, billboards and elsewhere, we all see new ads that encourage us to buy the product advertised. Why? Because it's new! If it's new it must be better, right?

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When you're trying to decide whether one car is better than another, you could use your own list of things you'd look for to compare the cars you're thinking about. Then you'd be ready to decide which car is the better one.

In science it is not unusual that more than one theory can explain a certain phenomenon. Or a new theory may be in conflict with an existing theory. Just as you decided which car would be best, scientists must decide which theory is best, and the newer theory isn't always the one chosen. The purpose of this activity is to help you experience one of the ways scientists decide which is the better theory, when more than one theory may seem correct.

OBJECTIVES

After you have completed this activity, you should be able to:

1. Name one kind of test a scientist may use on a theory.
2. Describe or give an example of how this test is used to decide which is the better theory.

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PROCEDURE

Materials: none.

To make a **prediction** is to use a theory to forecast data. To make a prediction is to tell what will happen in an experiment or observation before the experiment or observation is actually carried out. Predictions are educated guesses that follow from a theory. For example, imagine that you wanted to test a theory about the geologic history of a certain place and the theory stated that at one time that place was part of an ocean. From that theory, you would predict that the area should contain fossils of sea life that lived in that ocean. If such fossils were then found, the prediction would have been correct. A correct prediction supports a theory.

Now you are going to participate in an activity in which you will use predicting to help you decide which is the better theory, the **Conventional View of the Earth** or the **Plate Tectonics Theory.** In order to refresh your memory about each of these theories, a brief review is provided below.

TWO THEORIES ABOUT THE EARTH

The Conventional View of the Earth

Historically, the generally accepted view of the earth has been that it is made of a continuous, relatively rigid crust much like the skin of an apple. This position holds that beneath the crust is a molten fluid mass that makes up most of the volume of the planet. The surface of the earth is, therefore, somewhat stable and unchanging, except for erosional and mountain building forces that act independently in relatively small areas of the surface of the earth. Though this view of the earth is not a clearly defined theory statement, we will call it the Conventional View and consider it a theory.

According to this theory, the earth was formed as a molten mass which cooled. Cooling of the surface resulted in the solidification of the crust. Thus, all the oldest rocks were formed at the same time. Because cooling usually results in shrinking or contraction, this shrinking caused a wrinkling of the crust that led to the formation of the topographical features we recognize as mountains and valleys.

Since the time the earth cooled—when rocks were formed—erosional and mountain building forces have continually made changes in the face of the earth. The formation of **sediments** began at that time and have continued (except for local interruptions) throughout the history of the earth. Sediment is fragments of rocks and minerals, usually deposited in water.

The Plate Tectonics Theory

More recently in geology, the Plate Tectonics Theory about the nature of the earth has been proposed. Like the Conventional View, this new view also considers the earth as consisting of a thin crust with a molten core, but it differs from the Conventional View in that the crust is believed to be made of a series of about 12 to 14 relatively rigid sections or plates. Furthermore, these plates are believed to be in constant motion in relation to each other. Though this relative motion is very slow when compared to the things we see moving about us daily, it suggests that these plates don't stay in the same place, nor do they stay the same size or exactly the same shape. Plates continuously get new material at ridges and lose older material at trenches. Thus, rocks are being formed at the ridges throughout the life of the planet. Existing plates may, therefore, increase or decrease in surface area. In some locations, new plates are being formed. In some cases, evidence suggests that plates have completely disappeared.

Prediction Test #1: Dating Core Samples

You are part of a geologist's team which has received a grant to drill and date five core samples from an area just west of the East Pacific Rise and south of the Galapagos Fracture Zone.

Your team is going to use this opportunity to test the Conventional View and Plate Tectonics Theory. You will test these theories by predicting the relative ages of igneous rock cores that will be found at the drill sites. See Figure 1. Your task is to use these two theories to select and report the predictions you feel best follow from each theory. In addition, you will also be invited to discuss why you chose that particular prediction.

Using the **Conventional View**, check the following prediction that best indicates the relative ages of the sediment cores to be taken from drill sites A through E in Figure 2.

A • B • C • D • E •

_____ #1 oldest ⟷ youngest

_____ #2 youngest ⟷ oldest

_____ #3 All sites will be the same.

_____ #4 Each of the sites will be different ages, but ages will be randomly distributed.

I predict this will be found because the **Conventional View** says:

Using the **Plate Tectonics Theory**, check the following prediction that best indicates the relative age of the cores to be taken from drill sites A through E.

A • B • C • D • E •

_____ #1 oldest ⟷ youngest

_____ #2 youngest ⟷ oldest

_____ #3 All sites will be the same.

_____ #4 Each of the sites will be different ages, but ages will be randomly distributed.

I predict this will be found because the **Plate Tectonics Theory** says:

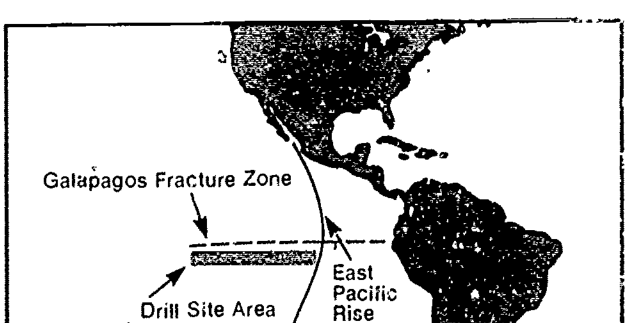

Figure 1. Drill site area for dating core samples.

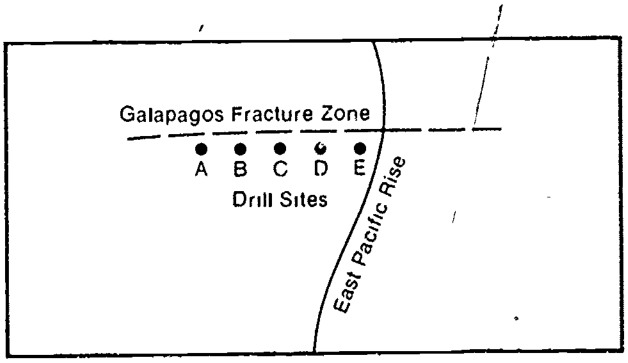

Figure 2. The drill sites will be approximately 500 km apart, with Site E at 500 km from the ridge and Site A at 2500 km from the ridge.

Prediction Test #2: Measuring Sediment Thickness

While your team was preparing for your trip to take core samples, the National Science Foundation contacted your group to request that you also measure the thickness of the sediment at those sites. In reviewing this request, it seems that this will give you another opportunity to test the Conventional View and Plate Tectonics Theory by predicting some other data. Since this request includes additional funding to support the added work, your team agrees to gather these additional data.

Before you make your prediction about the sediment thicknesses using the two theories, review the drill core plan. (See Figure 2.)

Using the **Conventional View,** check the following prediction that best indicates the relative thickness of the sediment from drill sites A through E.

A • B • C • D • E •

_____ #1 ←→ least sediment thickness ... greatest sediment thickness

_____ #2 ←→ greatest sediment thickness ... least sediment thickness

_____ #3 Sediment thickness the same at all sites.

_____ #4 Sediment thickness different at each site, but no pattern to thickness.

I predict this will be found because the **Conventional View** says:

Using the **Plate Tectonics Theory,** check the following prediction that best indicates the relative thickness of the sediment from drill sites A through E.

A • B • C • D • E •

_____ #1 ←→ least sediment thickness ... greatest sediment thickness

_____ #2 ←→ greatest sediment thickness ... least sediment thickness

_____ #3 Sediment thickness the same at all sites.

_____ #4 Sediment thickness different at each site, but no pattern to thickness.

I predict this will be found because the **Plate Tectonics Theory** says:

Let's review what you have done in this exercise. You chose one theory over another. The Plate Tectonics Theory makes accurate predictions more often than the Conventional View of the Earth. You chose the Plate Tectonics Theory because it made the best predictions. The more accurately a theory predicts, the more confidence you have in the theory.

Other ways to judge a theory might be:

1) It accounts for more or all of the present data better than the other theory or theories.

2) It accounts for new data better than the other theory or theories.

3) It is accepted by more scientists who work in that science.

Usually one theory is judged better than another because it holds up better under several different tests. However, based on this activity, your degree of confidence in a theory depends upon how well it predicts. The more correct predictions, the more confidence you should have in the theory.

SUMMARY QUESTIONS

1. You are a geologist and have a theory that states, "new ocean floor material is being created at mid-ocean ridges and destroyed at trenches." One prediction you might make is that all ocean floor material is less than 200 million years old. How could you check your theory?

2. Explain how predictions can be used to strengthen your confidence in a theory.

3. A geologist has a theory that states "the continents are not drifting." How could you check out this theory? How confident would you be in your results?

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EXTENSIONS

Using data about paleomagnetic anomalies, heat flow, seismicity or volcanic activity, make predictions using the two theories.

Review positions taken by noted geologists and geophysicists in various magazines regarding both theories as another way to decide which is the better theory.

REFERENCES

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Wyllie, P.J., 1976, *The way the earth works: an introduction to new global geology and its revolutionary development.* New York, John Wiley and Sons, Inc., 296 p.